Materials used in Concrete Construction

V. A. Houghton

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A STUDY OF MATERIALS

USED IN

CONCRETE CONSTUCTION.

A THESIS

PRESENTED BY

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PRESIDENT AND FACULTY

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INTRODUCTION.

The object held in view in this thesis work has been two fold. One part consisted in collecting a library of the materials used in concrete construction and also all the available information obtainable about them.

The other part was the study of the materials in general; their production, the methods of testing and general characteristics.

In this brief article the manufacture and method of testing cement was first taken up. Sands, gravels and crushed stone ware next discussed. A brief individual mention was then given to the samples collected, first the cements and then the other materials. A small bibliography is also appended for the benefit of those interested in the subject.

C E M E N T.

Although cement has been used for at least over 20 centuries and probably more, at no time have such tremendous strides been made in the improvement and use of cement as at the present. It will be attempted here to mention and describe a few of the chief points about cements used in concrete construction.

There are practically three classes of cements which are used in concrete construction and they are Portland, natural and slag cements. They rank in favor and usefulness in the order named, the first and last being results of artificial mixtures. Portland cement is produced by burning at heat just short of incipient fusion an intimate mixture of cement rock and limestone, clay and marl, chalk and clay or any argillaceous material and a calcareous material mixed in the proper proportion. The resulting clinker is ground to an impalpable powder, which is the finished product. Natural cement is produced by burning natural cement rock which has been reduced to kiln size by crushing and grinding the clinker to an impalpable dust. Natural cements are burned at lower temperature than Portland cements, although in some cases it is difficult to distinguish the two kinds.

Puzzolan cement, to which slag cement belongs, is produced by intimately mixing and grinding to an impalpable powder slaked lime and slag or other siliceous material, such as puzzolana, trass or burnt clay, without subsequent calcination.

A brief description of the processes in vogue, and the details of manufacture will be given for the various cements, starting with

Portland cement. The process used all depends upon the kind and condition in which, the raw materials are found. Availability of fuel, relative location of raw materials and transportation facilities are all important factors.

The dry process is suitable for materials such as limestone and clay or shale and cement rock and limestone.

Rock from the quarries is crushed with two or more sets of crushing machinery and then dried. Thorough mixing of the constituents is then accomplished and the material mixed proportionately is finally ground. The powder is then burned, in case other than rotary kilns are used, it is first moulded into bricks, and the resulting clinker is finely ground.

It is usually customary to season the cement in storehouses, and also add a small amount of gypsum, not to exceed two per cent in order to make the material more slow in its setting properties.

The wet process is best adapted for materials acted easily upon by water and is usually employed where the raw materials are marl and clay. In case the marl is submerged it is usually dredged and if a large enough per cent of water is present, say over 40 per cent, it is usually pumped to the grinding mill. Proper amounts of the raw materials are ground, it being necessary to dry one or both of them for accurate proportioning, and are then mixed in pug or wash mills. Some foreign plants omit the agitators in these mills. The slurry is then run off and allowed to settle. The old method was to cut the slurry in bricks after it had dried, and

then calcine it, but the method is rapidly falling into disuse. Nowadays the wet slurry is pumped direct to rotary kilns where it is dried in the upper end and burned in the lower end. The clinker is then finely ground. Both these processes are subject to great variation to suit the conditions of material and other factors.

Although in general the processes throughout the country are much the same, the details of manufacture vary immensely, depending chiefly upon the character and location of the raw materials. In case the raw material is a submerged marl it is usually dredged and is then pumped to the drying and mixing mill. Semi-dry marls and clays are removed by steam shovels or hand labor and are either carted or transported by cars to the plant. Cement rocks, limestones, and the sort are usually obtained from open faced quarries. The material is drilled, blasted and then removed by hand labor or steam shovels to cars or carts.

As may be realized the all important factor in successful cement manufacture is the proper mixing of raw materials. For this reason analysis are made constantly and large stores of the raw material are kept on hand. About the first step is the drying of the materials. Wet marls and clays are run into long cylindrical driers, the ends of which are incased in brick fire chambers. The material after being dried, is pulverized and is then ready to be mixed. Chief among the rotary driers in common use are the Cummer, Mosser and Ruggles-Cole Co's. driers. Cement rocks, limestones and dry materials are crushed with either the Blake or Gates crushers, and are then mixed. In some cases the mixing takes place after the

fine grinding has been done. Formerly fine crushing was accomplished by means of buhr mills, but the present process adopted,is what is known as gradual reduction. "The forms of machinery now used are either mills like the Griffin, Huntingdon or Kent, which are iron mills of the centrifugal type, having a ball or balls operating upon the raw material, or any of the forms of tube or ball mills, where the grinding is done by the attrition of Iceland pebbles or steel balls upon the material to be treated.

The distinction between these mills is that the latter will take care of stone of almost any size that can be introduced through the feed hopper, while in gyratory centrifugal mills a system of gradual reduction by passing through Mosser crushers and through Buchanan rolls is necessary for the greatest efficiency." (Brown pp.33)

The next step in the process is the burning, and for this part of the manufacture many types of apparatus have been designed. The rotary kiln is installed almost exclusively in modern plants, and the other types will be given only brief mention.

The kilns used when the industry first started in the United States were dome kilns, so named to their resemblance to a dome. W W, These were charged with alternate layers of raw material bricks and fuel, and the charge ignited at the bottom and allowed to burn out. This process was intermittent and and comparatively slow. Other kilns, namely, those of the Dietzsch, Shoefer and Hauenschild type belong to the class known as chamber kilns. These kilns are regularly charged every so often with fuel and bricks at the top. The combustion takes

means

place in the middle chamber of the kiln and the material after being burned drops to the lower chamber and is removed. There is considerable waste attendant to the use of these kilns however, because overburned and underburned clinker must be rejected.

The rotary kiln is essentially a cylindrical chamber set on a slight slant, and mounted so that it may be revolved. The shell is of iron and the lining is fire brick. The average length was 60 feet with a diameter of 60 inches at the chimney end and 66 inches at the discharge end until within the last five years. The tendency seems to be now to increase the length up to about 80 or 90 feet and the diameter accordingly. The operators using larger kilns assert that they are satisfactory as they are more economical in the use of fuel per barrel of product. The largest installation of rotary kilns yet made is that of the Edison Portland Cement Company of Stewartsville, N.J.; these kilns are 150 feet long. The fuels used are natural gas, oil and powdered coal, the latter being used in the majority of cases. At present natural gas is used most in Kansas and oil on the Pacific Coast. The raw material, whether wet or dry, is fed into the upper end of the kiln and gradually works down, being dried and burned on the way. The fuel is admitted at the discharge, or lower end of the kiln. After the burning is complete, the clinker is removed and cooled, sometimes by water spray and sometimes with air alone.

Grinding is next on the program and many kinds of mills have been devised. Two processes are of grinding are in use. They are, first, grinding with batteries of ball and tube mills and second, using

gyratory centrifugal mills of the Griffin or Huntingdon type. If the first is adopted the clinker may be fed directly to the mills, but if the second is adopted gradual reduction must be employed.

"The ball mill is a short cylinder of large diameter which is partially filled with flint or steel balls. When the cylinder revolves the balls and clinker fall upon the hard metal surfaces, and as the material is ground to the size of sand grains, it falls through screens in the periphery into a hopper, where it is delivered to a conveyor or another form of pulverizer for further reduction." (Sabin pp 20)

"The tube mill is a steel cylinder, about four or five feet in diameter and fifteen to twenty-five feet long, with axis horizontal or nearly so, and revolving on trunnions. The cylinder is lined with hard iron or porcelain and is half filled with flint pebbles. The material is fed in at one end and is gradually pulverized as it works toward the other end. Some styles are not continuous in their action but are charged and closed, the material being removed after a certain number of revolutions." (Sabin pp.21)

The Griffin mill consists of "a heavy steel roller attached to the bottom of a steel shaft, which is provided at its upper end with a ball-and-socket joint. When the shaft is given a gyratory motion, the roller presses by centrifugal force against the inside surface of a heavy steel ring where the grinding takes place. The material which drops below the roller is thrown up again by steel blades that are also attached to the shaft, and when finally of

sufficient fineness, the powder escapes through screens above the ring into a hopper." (Sabin, pp 21)

There are variations of all these mills under different names but the principles are about the same. The Edison Portland Cement Co. have installed heavy rolls both for crushing and grinding the raw material and the clinker. These rolls are pressed together with a pressure of 18,000 lbs. per square inch by means of a compressed air device. Heavy rolls have been used by other manufacturers with good success.

Coal grinding is another important item in a cement plant and is usually accomplished with gyratory centrifugal mills. The pulverized material has to be carefully stored to avoid explosion and absorption of moisture. The cement, after a sufficient quantity of gypsum has been added to retard the setting properties, is stored and seasoned. It is then packed in bags or barrels as needed for shipment.

As previously stated natural cement is produced from the natural cement rock. This rock is limestone of an argillaceous, magnesian or argillo-magnesian character. The first named limestone produces an aluminous cement, the essential ingredient being bisilicate or silicate of alumina and lime, while the magnesian limestone produces a magnesian cement, the essential ingredient being tri-silicate of lime, magnesia and alumina.

The usual method employed in quarrying the rock is open face cutting but sometimes tunnels are used. The rock is conveyed to crushers which break it up into sizes not greater than six inches and

blanks.

is then taken to the kilns. The kilns that are used for natural cement burning are, as a rule, of the vertical type. The crushed rock and fuel are charged in the top of the kiln in alternate layers and either bituminous or anthracite coal may be used. After the burning the rock is crushed, screened and ground.

The crushing is done usually with what is known as a "cracker" and the grinding with mill stones. The natural cement works at Utica, Illinois employ ball and tube mills for grinding, and as a matter of fact many plants deviate quite considerably in some parts of the process. After the clinker has been reduced to an impalpable dust it is thoroughly mixed in order to give uniformity. The cement is then stored and put up as needed for shipment.

Slag cement is produced by intimately mixing slaked lime and granulated slag, which has been obtained from grey iron cupalos. The general method followed is to spray the slag as it comes from the furnace with water or steam, which disintegrates the granules and makes them porous. The granules are then powdered and mixed with powdered lime in the proper proportion determined by analysis; grinding and sifting are then carried on until the proper fineness and homogeneity are attained. The grinding is done usually by means of Griffin and tube mills and an addition of caustic soda is made to render the cement quick setting. The cement is then ready for storage.

Mention might be made here of slag Portland cement. In this cement the silica ingredient is supplied by the addition of slag. The slag is prepared as in slag cement manufacture by running it into

water or spraying. It is thus granulated and the sulphur ejected to a large extent. The slag is then mixed in the correct proportion with limestone and from this point on the process of manufacture is identical with that used for Portland cement.

Still another Portland cement is made from the bi-products of alkali manufacture at Wyandotte, Michigan. The waste limestone is mixed with clay in the proper proportion and Portland cement by the wet process is manufactured.

What is known as sand or silica cement is a mechanical mixture of preferably one part of cement to one part of sand, which is ground to extreme fineness in tube mills. This cement is only very little higher priced than ordinary cement and claims great strength considering the adulteration. It has been used quite extensively in government work by army engineers.

TESTING OF CEMENT

In scarcely any branch of testing have as many changes and standards been made as in cement testing. Although it is a recognized fact that the cement tested is far different than the concrete into which it is made, certain tests give the experimentor a fairly good idea as regards what to expect.

The principal tests applied are specific gravity, fineness, normal consistency, soundness, tensile strength and time of set. Chemical analysis is also important and is universally applied to cement which is to be used in work of any extent.

The methods of testing adopted by the American Society for Testing Materials as given in the Handbook for Cement Users by Mr. C. C. Brown, pages 46 to 52, will be given.

"Specific Gravity--The determination of specific gravity is most conveniently made with the Le Chatelier's apparatus. This consists of a flask of 120 cu. cm. (7.32 cu. ins.) capacity, the neck of which is about 20 cm. (7.87 ins.) long; in the middle of this neck is a bulb, above and below which are two marks, the volume between these two marks is 20 cu.cm. (1.22 cu. ins.). The neck has a diameter of about 9 mm.(0.35 in.), and is graduated into tenths of cubic centimeters above the upper mark.

Benzine (62 degrees Baume naphtha), or kerosene free from water, should be used in making the determination.

The specific gravity can be determined in two ways:-

(1) The flask is filled with either of these liquids to the lower mark, and 64 grams (2.25 oz.) of powder, previously dried at

100° C.(212° F.) and cooled to the temperature of the liquid, is gradually introduced through a funnel (the stem of which extends into the flask to the top of the bulb), until the upper mark is reached. The difference in weight between the cement remaining and the original quantity (64 gr.) is the weight which has displaced 20 cu.cm.

(2) The whole quantity of the powder in introduced, and the level of the liquid rises to some division of the graduated neck. This reading plus 20 cu. cm. is the volume displaced by 64 gr. of the powder.

The specific gravity is then obtained from the formula:

$$\text{Specific gravity} = \frac{\text{weight of cement}}{\text{displaced volume}}$$

The flask, during the operation, is kept immersed in water in a jar, in order to avoid variations in the temperature of the liquid. The results should agree within 0.01."

"Fineness --The sieve should be circular about 20 cm.(7.87 ins.) in diameter, 6 cm. (2.36 ins.) high, and provided with a pan 5 cm. (1.97 ins.) deep, and a cover.

The wire cloth should be woven (not twilled) from brass wire having the following diameters:-

No.100, 0.0045 in.; No.200,0.0024 in.

This cloth should be mounted on the frames without distortion; the mesh should be regular in spacing and be within the following limits:

No.100, 96 to 100 meshes to the linear inch.
No.200,188 to 200 meshes to the linear inch.

Method. The thoroughly dried and coarsely screened sample is weighed and placed on the No.200 sieve, which with pan and cover attached is held in one hand in a slightly inclined position, and moved forward and backward, at the same time striking the side gently with the palm of the other hand, at the rate of about 200 strokes per minute. The operation is continued until not more than one tenth of one per cent passes through after one minute of continuous sieving. The residue is weighed, then placed on the No.100 sieve and the operation repeated. The work may be expedited by placing in the sieve a small quantity of large shot. The results should be reported to the nearest tenth of one per cent."

"Normal Consistency- Method.This can best be determined by means of a Vicat Needle apparatus, which consists of a frame, bearing a movable rod, with a cap at one end and at the other a cylinder,1 cm. (0.39 in.) in diameter, the cap, rod and cylinder weighing 300 gr. (10.58 oz.). The rod, which can be held in any desired position by a screw, carries an indicator, which moves over a scale (graduated to centimeters) attached to the frame. The paste is held by a conical, hard-rubber ring, 7 cm. (2.76 ins) in diameter at the base and 4 cm. (1.57 ins.) high, resting on a glass plate about 10 cm. (3.94 ins.) square.

In making the determination, the same quantity of cement as will be subsequently used for each batch in making the briquettes (but not less than 500 grams) is kneaded into a paste, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained 6 ins. apart; the

shot.

ball is then pressed into the rubber ring, through the larger opening smoothed off, and placed(on its large end) on a glass plate and the smaller end smoothed off with a trowel; the paste, confined to the ring, resting on the plate, is placed under the rod bearing the cylinder, which is brought in contact with the surface and quickly released.

The paste is of normal consistency when the cylinder penetrates to a point in the mass 10 mm. (0.39 in.) below the top of the ring. Great care must be taken to fill the ring exactly to the top.

The trial pastes are made with varying percentages of water until the correct consistency is obtained."

"Time of Setting--Method. For this purpose the Vicat Needle, which has already been described, should be used.

In making a test, a paste of normal consistency is molded, and placed under the rod; this rod, bearing a cap at one end and a needle, 1 mm. (0.039 in.) in diameter, at the other, weighing 300 gr. (10.58 oz.). The needle is then carefully brought in contact with the surface of the paste and quickly released.

The setting is said to have commenced when the needle ceases to pass a point 5 mm. (0.20 in.) above the upper surface of the glass plate and is said to have terminated the moment the needle does not sink visably into the mass."

Other points mentioned are as follows: The test pieces should be kept moist during the test; the needles should be kept clean; the test is materially effected by temperature and quantity of mixing

terminator

water, humidity of the air and amount of mixing administered.

"Tensile strength--The test may be made on any standard machine. A solid metal clip is recommended. This clip is to be used without cushioning at the points of contact with the test specimen. The bearing at each point of contact should be a quarter of an inch wide and the distance between the centers of contact on the same clip should be one and one quarter inches.

Test pieces should be broken as soon as they are removed from the water. Care should be observed in centering the briquettes in the testing machine, as cross strains, produced by improper centering, tend to lower the breaking strength. The load should not be applied too suddenly, as it may produce vibration, the shock from which often breaks the briquette before the ultimate strength is reached. Care must be taken that the clips and sides of the briquette be clean and free from grains of sand or dirt which would prevent a good bearing. The load should be applied at the rate of 600 pounds per minute. The average of the briquettes of each sample tested should be taken as the test, excluding any results which are manifestly faulty."

The society prescribes the use of a one to three sand mixture for mortar briquettes, the sand used being standard obtained at Ottawa, Ill.,which will pass a 20 mesh sieve and be retained on a 30 mesh sieve.

"Constancy of Volume--Methods. Tests for constancy of volume are divided into two classes: (1) normal tests, or those made in either air or water maintained at about 21° C. (70° F.) and (2) accelerated tests, or those made in air, steam or water at a temperature of 45° C.

(115°F) and upward. The test pieces should be allowed to remain 24 hours in poist air before immersion in water or steam, or preservation in air.

For these tests, pats about 7 1/2 cm. (2.95 ins.) in diameter, 1 1/2 cm. (0.49 in.) thick at the center, and tapering to a thin edge, should be made, upon a clean glass plate (about 10 cm.(3.94 in.) square), from cement paste of normal consistency.

Normal test. A pat is immersed in water maintained as near 21° C. (20° F.) as possible for 28 days, and observed at intervals.

Accelerated Test. A pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel.

To pass these tests satisfactory, the pats should remain firm and hard, and show no signs of cracking, distortion or disintegration.

Should the pat leave the plate, distortion may be detected best with a straight-edge applied to the surface which was in contact with the plate."

The method of analysis recommended is "that proposed by the Committee on Uniformity in the Analysis of Materials for the Portland Cement Industry of the New York Section of the Society for Chemical Industry."

Concerning tests made by myself, I would say the following; for tensile tests, a Fairbanks standard machine was used and the briquettes tested were composed of one part water, two parts cement and six parts sifted torpedo sand for Portland cement briquettes

and 8 1/2 parts water, ten parts cement and ten parts sifted torpedo sand for natural cement briquettes; for fineness tests, Riehle U.S. standard sieves of 100 and 200 mesh wire used; for the determination of initial and permanent set Gilmore needles were used. "One of there wires is 1/12 inch in diameter and is loaded to weigh 1/4 pound; the other is 1/24 inch in diameter and is loaded to weigh one pound. The paste is said to have reached "initial set" and "end of set" when these two wires, respectively, fail to make an impression on the surface."("Concrete & Cement," Sabin,pp 66). In other respects the specifications given were followed.

These tests all have a certain significance, about which a few remarks will be made.

The specific gravity test is frequently of value in determining whether a cement has been overburned, underburned or adulterated. An unusually high specific gravity will sometimes indicate overburning, which causes the cement to deteriorate as it ages and low specific gravity may indicate unburning or adulteration both of which decrease the strength of the cement.

The fineness of cement is a very important factor, because it is the impalpable dust which possesses the cementitious and sand bearing properties. The larger particles are either inert or only moderately active and work made with coarse cement will be liable to swell and crack due to the lack of uniformity of the mass.

The value of the normal consistency test will be readily realized when the difference of various cements is noted. Different

cements require different percentages of water for the best mixture and it is by the application of this test that the proper percentage is determined. Time of set must always be considered, because it may result in subsequent weakness if the cement is disturbed during set. The value of strength and soundness are evident.

Specifications for cement are without number and nearly every railroad, engineering company, or extensive cement user in the country has a particular set of specifications. A few general remarks concerning the characteristics of cements might be made at this point however.

Portland cements vary in specific gravity from 3.1 to 3.25, slag cements from 2.7 to 2.8 and natural cements from 2.5 to 2.8

Army engineers require that 92 per cent; 80 per cent, and 97 per cent shall pass a 100 mesh sieve for Portland, natural, and slag cements respectively.

They also require that a Portland cement shall not acquire its initial set in less than 45 minutes or its permanent set in more than ten hours, that a natural cement shall not acquire its initial set in less than 20 minutes or its final set in more than four hours, and that a slag cement shall not acquire its initial set in less than 45 minutes or its final set in more than 10 hours. The sets are determined with Gilmore needles.

Their requirements for tensile strength of neat briquettes in pounds per square inch are as follows: Portland cements shall develop 450 pounds after seven days and 540 pounds after twenty-eight days;

natural cements shall develop 90 pounds at the end of seven days and 200 pounds after 28 days; and slag cements shall devepol 350 pounds after 7 days and 500 pounds after 28 days. (Eng. News Sept. 12, 1901; Report of the Board of Engineers, U.S.A., on the properties and testing of Hydraulic Cement.)

Concerning the boiling or accelerated soundness test, some companies will reject a cement if it fails in this respect, while other concerns will not consider this test at all if the cement passes the other requirements.

Generally speaking cement is produced all over the country. Without doubt Portland cement could be produced in any state in the union. The main consideration when selecting a site however are the proximity of raw material deposits, transportation facilities, and fuel. Natural cement plants seem to cluster in regions. The principal natural cement districts are the Rosendale, Lehigh, Maryland and Kentucky. Large plants are also located in Illinois and Wisconsin and others are scattered about the southern and western states. Slag cement is manufactured at eight plants distributed through seven states.

SAND, GRAVEL and CRUSHED STONE.

Under the above head will be considered the other materials used in concrete construction besides cement. Although the cement is the prime factor in successful concrete construction, there are many items of importance to be considered concerning the other materials.

Sand will be considered first and may be said to be divided in two classes, viz., either natural or artificial.

Natural sand is obtained from banks, rivers or ocean beaches and artificial sand is produced by crushing, grinding and then sifting rocks of either a calcareous or siliceous composition.

The various kinds of sand might be mentioned and are as follows:-

Lake, bank, torpedo and quartz natural sands and the artificial sands produced from different kinds of stone. Torpedo sand is most generally used in concrete construction, although limestone screenings are coming into considerable favor; the latter has shown superiority in tests made by good authorities.

Usually sands are removed from these sources, if not submerged, by means of hand labor or steam shovels. The latter method is more satisfactory as a rule if the source of material is of sufficient size to warrant the installation of the tracks and accessories. Sand from lakes and rivers is gotten by dredging. Sometimes the material is pumped to the point where it is to be cleaned and dried and sometimes it is transported on scows.

When a sand is to be selected there are several characteristics which should be considered. The nature of the sand, whether it be

calcareous or siliceous is not of prime importance. Tests made by M. Alexandre (Table 46 "Cement and Concrete,"Sabin") and others show results that average fairly well for both kinds, using different mixtures with respect to fineness and percentage of voids. Limestone screenings and in fact most artificial sands seem to show superiority in mortar. This is probably due to the shape and grading of the particles more than the physical character, because it is a fact that the sand does not necessarily have to be more than moderately hard to be first class.

The shape and soundness of the grains of a sand is a matter that deserves attention. It is evident that angular and sharply cornered grains will form a better bond than smooth rounded ones. Sands which show evidences of decay are to be avoided, since failure may result to the work which contains decaying material.

The fineness of the sand used is a matter that must always be considered and size and shape of grains are important elements. "Considering grains of the same shape but differing in size, the larger grain will have a smaller surface area in proportion to the volume than the smaller grain, since the volume varies approximately as the cube of one dimension while the surface varies as the square. Since, in order to obtain the best results in mortar, each grain of sand must be coated with cement, it follows that, other things being equal, the coarser grained sands will give the best results, because they will be more thoroughly coated; this will be especially true when the amount of sand in the mortar is relatively large."

(Cement and concrete, by Sabin,page 159).

Angular grains although having more relative surface area are to be preferred however, and mixtures of fine and course sand give the best results. If a selection is to be made however between fine and coarse sands the coarse is always preferable, its superiority having been demonstrated by many authoritative tests.

Voids in sand have a decided effect upon the cost of concrete construction, since it will be remembered that they must be filled with cement in order to make a good aggregate. "The voids present in a given mass of sand will depend upon the shape of the grains, the degree of uniformity in size of grains, the amount of moisture present and the amount of compacting to which the mass has been subjected." (Concrete and Cement, Sabin,page 162).

Tests made on sands having the same granulometric composition or degree of uniformity in size of grains by M. Feret show rounded grains to have the smallest percentages of voids, then angular grains, next flat grains and finally laminated grains have the largest percentage.

The characteristics above mentioned vary with every sand from every source and it is customary for companies controlling sand pits or banks to have screening apparatus installed in order to produce uniform material, or material graded and mixed as the customer desires. Concerning moisture, this much may be said, that a small amount will have considerable effect, because each grain is coated with a film which prevents compactness and the voids are thereby much increased.

Impurities in sand are to be avoided as a rule, and if the foreign substance is really injurious much care must be taken to remove it. Clay and loam up to 10 or 15 per cent are allowable and have been shown to have no bad effect, in fact the opposite being true as shown by many conclusive tests. See Geological Survey of Ohio, Eno, pp. 34 and 35 and Cement and Concrete, Sabin pp, 168 and 169. All the better grades of sand are washed nowadays and practically all impurities removed. There are several designs of apparatus used for sand washing but the two most generally used are the tubular and the cylindrical washers.

Sabin gives an excellent set of requirements for a good sand in his book on cement and Concrete, which are as follows:- "In conclusion, then, we may say that good sand may consist of grains of almost any moderately hard rock that is not liable to future alteration in the work. The grains may be of any shape, but preferably should be sharp and angular or lenticular in form, not rounded and smooth. The sand should not contain such impurtities as loam or humus, but for most purposes a small percentage of clay or fine rock dust is not objectionable. Clay should not however be permitted in sand for use in sea water.

Coarse grained sands are better than fine grained ones, but a mixture of fine and coarse is excellent, especially where but a small amount of cement is used, because such a mixture contains less voids and will make a less permeable mortar, while giving a good strength. As might be expected the deleterious effect of poor sand is more apparent the larger the dose of sand used."

No definite relation can be established between the fineness and percentage of voids but as has been already said, the coarser the sand, the smaller the percentage of voids. By referring to the catalogue of materials individually described later one may draw their own conclusions. In brief however torpedo sands may contain from 24 per cent to 28 per cent voids and sifted torpedo up to 30 per cent. Mixtures of fine gravel such as a half and half mixture of numbers two and four will contain from 23 to 25 per cent voids and granite siftings about 22 per cent. Limestone screenings contain about 18 per cent of voids when well mixed and graded. Quartz sand tested by myself was found to contain 28.6 per cent voids and crushed quartz of very uniform size was found to contain 41.7 per cent voids. Riehle U.S. standard sieves were used for determining the fineness. The method used for determining voids was as follows:- Into 100 cc. of water contained in a cylindrical graduate, sand was poured and packed down with a brass rod until water and sand came to the same level. The total volume divided into 100 gave the ratio of the sand to the voids.

Gravel may next be considered. Practically all that has been said about natural sands may be applied to gravels. They are procured from banks and pits and are removed by steam shovels or hand labor. The ordinary run of gravel is composed of rocks that are much harder than limestone although this is not absolutely necessary. With gravel as with sand, impurities and foreign substances are to be

avoided. The effect of impurities is more noticeable with gravel however because a coating is usually formed on the surface which prevents a good bond. After gravel has been removed from the source it is screened and washed and often times sorted. The different sizes are then sold for different purposes. Due to the smooth and rounded surfaces of gravel it does not make as good a bond as crushed limestone and therefore is not as popular. Lately however some gravel companies have installed crushers of either the gyratory or jaw type, which crack the larger pebbles, producing pieces with sharp and angular edges. The smaller pebbles act as sort of a filler reducing the voids, and the aggregate produces an excellent concrete, which bears comparison with crushed limestone aggregate.

The gravel used in concrete construction is usually designated as No.7 or No.8 and will pass one inch and one and one half inches rings respectively. It all depends upon the judgment of the engineer or architect or the magnitude of the piece of work, which will be used. Gravels sometimes designated as concrete gravels and bearing the same numbers as the above have an addition of finer material which improves the aggregate. Roofing gravel is usually designated as No.5 and is rarely used in concrete work. Roughly speaking gravels possessing fair uniformity may be said to have about 40 per cent voids.

Crushed stone, although from a natural course is practically a manufactured product. The stone usually used in concrete work is limestone and is quarried from surface cuts as a rule either by hand labor or explosives. The stone is then transported to the

crushers, which are either of the gyratory or jaw type as a rule. The gyratory crusher consists of an inverted conical shell within which a heavy and slightly conical head gyrates eccentrically. The stone is crushed between the head and the shell. The jaw crusher has for its essential parts a pair of jaws, one sationary and the other actuated by an eccentric, which tends to draw the material in. The gyratory crusher claims greater efficiency and a more cubiform and uniform product.

After crushing, the material is screened either by gravity or revolving screens, the latter are more efficient and produce more uniform results. A revolving screen is merely a cylindrical screen laminated in sections having different sized apertures. The material is fed in and is thus sorted in the different sizes, which are used for different sizes of work.

Concerning the adaptability of any stone to use in concrete, there are a few points to be considered. The best stone is tough, moderately hard and angular. Stone, which is decayed should be rejected and foreign substances and dirt are not permissable. A small amount of dust is permissable in the screenings. Mixing the large and small pieces produces an excellent aggregate but the more uniform product is used to a greater extent than in the case of gravel. It might be well to say that gravel or crushed stone should always be well wetted before mixing.

The voids in crushed stone are about the same as in gravel, averaging roughly forty per cent. A mixture of a large and small

size reduces voids to an extent, while the angularity tends to increase the percentage when compared to the smooth rounded pebbles of gravel.

The regular sizes of crushed stone are those which will pass 1/2", 3/4", 1", 1 1/2", and 3" rings. Then there are the coarse and fine screening and other sizes are sometimes produced. The 1/2", 3/4", and 1" sizes are classed as the sidewalk sizes and are used for sidewalks, gutters and floors. The 1 1/2" size is used for street paving, retaining walls, foundations up to a fair size and in fact for a large part of concrete work. The three inch size is used for heavy foundations, bridge piers and large abutments. Gen. Sooy Smith conceived the idea of using large bowlders and masses of concrete in heavy work, rather than crushing them and adding to the expense.

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Aetna Cement.

Aetna Cement is a Portland cement produced at Fenton, Mich. The raw materials used are marl and clay and the wet process is employed.

Tests made by Mr. O. Button gave the following results; fineness, 97 per cent passed a 200 mesh sieve, and 80 per cent passed a 100 mesh sieve; 1.84 per cent gypsum present; initial set took place in 3 1/2 hours and final set in 7 hours; the boiling test was O.K.

Neat briquettes made with 21 per cent water showed the following tensile strength in lbs. per square inch; at the end of one day 200 lbs, 7 days 620 lbs., and 28 days 780 lbs. Briquettes made with one part cement and three parts sand showed tensile strength of 115 lbs. per square inch at the end of 24 hours and 328 lbs. per square inch at the end of seven days.

The following is approximately the chemical analysis of the raw material and the cement:-

	Cement	Marl	Clay
SiO_2	23.17	2.20	60.00
Fe_2O_3 and Al_2O_3	10.70	1.24	20.88
Ca O	61.90	48.89	6.28
Mg O	2.50	1.07	3.09
SO_3	1.30	1.30	
Loss		45.30	9.10
Alkalis			1.90

The Aetna plant is a small one and the cement is not much used in Chicago.

Atlas Brand Portland Cement.

Atlas cement is a true Portland manufactured at Northampton and Coplay, Penna., in the Lehigh district. The raw materials used are cement rock and limestone and these are burned in rotary kilns.

The plant employs, what is known as the"dry" process, and one of the features of the plant is the belt conveying system. The cement produced weighs 400# gross and 380# net per barrel. The chemical analysis is as follows:-

SiO_2	21.30
Al_2O_3	7.65
Fe_2C_3	2.85
Ca O	60.95
Mg O	2.95
SO_3	1.81
$H_2 CO_3$	1.14
Potash	5.70
Soda	.63
Moisture	.27

The fineness determined with Riehle U. S. standard sieves is 97.3 through a 100 mesh sieve and 87.9 through a 200 mesh sieve. Tensile tests made by myself gave the following results:-

Time	Strength lbs. per square inch
1 day	145, 144
14 days	216, 199
21 "	205, 240, 222,216

All briquettes were made in the following proportions:-

15 ounces sifted torpedo sand, 5 ounces cement and

Atlas Brand Portland Cement, Cont.

2 1/2 ounces water. An average of about a thousand tests made in Chicago is given here

	24 hours	7 day	28 day	
Neat	280	700	900	strength
1 - 2 sand	80	250	400	lbs. per square inch

Tests made by Mr. O. Button with neat briquettes are as follows:-

24 hours	360	lbs. per square inch
7 days	715	" " " "
28 "	816	" " " "

The initial set of this cement takes place in approximately an hour and final set in eight hours. This cement was used quite extensively by the Chicago & Northwestern Railway in the track elevation work for wall foundations, masonry work and finishing mortar; 1 to 3 to 5 mixture being employed.

Burt Cement

This cement is a good example of a slow setting Western Portland cement and is manufactured at Bellevue, Mich., from cement rock and limestone. Tests made by Mr. O. Button, Superintendent of the Burt Portland Cement Co., are shown herewith-

Fineness — Preliminary tests

	Passing 100 mesh sieve	Passing 200 mesh sieve	Per cent water	Percent $CaSO_4$	initial set	final set	Boiling test
Oct.18	98	80	21	1.5	35 M.	4 1/2 H	O.K
	98	79	21	1.5	35	4 1/2	O K
	97	79	21	1.5	45	5 3/4	O K
	98	80	21	1.5	60	6 1/2	O K
	98	79	21	1.5	55	4 1/2	O K
	97	78	21	1.5	45	5	O K
Nov.21	99	81	21	2	40	4 1/2	O K
	99	80	21	2	45	4 3/4	O K
	98	79	21	2	50	4 1/2	O K
	98	80	21	2	45	4	O K
	99	81	21	2	45	4 1/2	O K
	99	80	21	2	45	4	O K

Tensile strength lbs. per square inch

	per cent water	24 hours	7 day	28 day	3 months
Oct.18	21	210	625	910	920
	21	235	595	900	1020
	21	225	550	700	915
	21	205	599	700	1010
	21	215	550	900	970
	21	220	515	670	905
Nov. 21	21	320	690	960	975
	21	310	790	925	950
	21	340	730	965	900
	21	355	640	930	940
	21	375	640	890	900
	21	355	690	870	880

Burt Cement, Cont.

Tensile tests made by myself with one to three sand mixture are as follows:-

	7 day	14 day	21 day
Lbs. per sq. in.	89	124	181, 195
	90	144	166 208

I found that 96 per cent passed a 100 mesh sieve and 91.3 per cent passed a 200 mesh sieve.

The average cost of this cement would be about a $1.50 per barrel; at present, however, the price is fluctuating rapidly.

Burt cement is new on the market, having been produced only in the last six months.

Edison Portland Cement.

As the name implies this cement is a Portland and is manufactured at Stewartsville, N.J. from argillaceous limestone of a soft, shaly character. A sufficient quantity of pure limestone is added to give an adequate amount of lime. The plant which is capitalized with $1,000,000, has a capacity of 10,000 barrels per day, and has many novel features.

Roll crushers are used instead of the standard crushing and grinding machinery for both the raw material and the clinker.. Rotary Kilns, 150 feet long and 10 feet in diameter and tapering at the chimney end are used. These kilns have a capacity of 30 barrels per hour and consume 80# of fuel per barrel, whereas the ordinary 60 foot kiln produces only from 7 to 10 barrels per hour and consumes from 80# to 140# of fuel per barrel. Still another departure is the substitution of vertical driers for rotary driers. A vertical shaft 8′ x 8′ x 40′ high, fitted with three sets of baffle plates, the top set being vibrated, has a current of hot air of passing through it and thus dries the material. The raw material grinding rolls are fitted with novel tension devices, which produce a pressure of 18,000 lbs. per square inch. Coal, which is powdered in ball and tube mills is used for fuel, and air separation is employed. Electric power is used throughout.

Tests made by Lathbury and Spackman are as follows:-

Fineness, 99.8 per cent through 100 mesh sieve; and
91.6 " " " 200 " "

Initial set, 2 hours; final set 6 1/2 hours 25 per cent of

Edison Portland Cement, Cont.

water used, temperature of air 72° and of water 73°

Boiling test O.K. and specific gravity 3.16

Neat		1 to 3 sand	
24 hour	7 day	7 day	28 day
313	325	250	329
306	710	283	319
379	690	242	326
300	669	255	338
328	655	244	346
Av. 325	Av. 676	Av. 255	Av. 331

The chemical analysis was as follows:-

SiO_2	20.14
Al_2O_3	7.51
Fe_2O_3	3.33
Ca O	62.71
Mg O	2.84
SO_3	1.64

Ratio of Ca O to SiO_2 is 3.11 to 1.00

Tensile tests made by myself gave the following results, 1 to 3 sand mixture being used:-

	Lbs. per square inch
7 day	230,205
14 "	252,226
21 "	247,270

Egyptian Portland Cement.

Egyptian brand of cement is a true Portland made at Benton, Michigan, by the wet process. Ball and tube mills are employed for grinding the slurry, clinker and the coal. The marl is dredged in the immediate vicinity, while the clay is obtained 25 miles away. The raw material is burned in rotary kilns, which have an aggregate capacity of 1000 barrels per day and the clinker is ground in 4 Gates ball mills and 2 Gates tube mills. Rope drive transmission is used throughout, the total horse power of the plant being 2600. The Company is capitalized for $1,050,000.

The chemical analysis of the raw material and of the cements are as follows:-

	Cement	Marl	Clay
SiO_2	23.17	2.20	60.00
Fe_2O_3 and Al_2O_3	10.70	1.24	20.88
Ca O	61.98	48.39	6.23
Mg O	2.50	1.07	3.09
SO_3	1.30	1.30	
Loss		45.80	8.10
Alkalis			1.90

The Egyptian Portland Cement Co. have no Chicago Agents.

The following table gives the chemical analyses of the ash of the **cements** used in the experiments described in this paper:—

Hydrolithic Cement Coating.

The so-called Hydrolithic cement coating is an ingredient, which, when mixed with good Portland Cement, produces a waterproof material. This ingredient is intimately mixed with either Medusa, Lehigh or Vulcanite cements by the manufacturers prior to removal from the plant, and is shipped out in bags or barrels in this form. This Hydrolithic cement is produced by The E. J. Winslow Company at South Chicago, and the firm also manufactures vaults and cisterns of their cement beside contracting for basement and tunnel construction.

The following rules must be heeded for successful application of the waterproofing material; a thorough and complete mixing must be accomplished, more by the application of the hoe than of water, and the surface to which the coating is applied must be perfectly clean. The process by which this waterproofing material is made is a secret one. Although no specific data was available, I found that the cement after mixing with the waterproofing substance was finer and had a slightly higher specific gravity and was informed that the ingredient had no deleterious effect upon the strength. A 5/8 inch coating will withstand a pressure of 130 lbs. per square inch.

Medusa Portland Cement

This cement is produced at Sandusky, Ohio, by the wet process. The raw materials used are marl and clay, and these are burned in rotary kilns. Griffin mills are used to grind the clinker, which is a very uniform product. The fineness of this cement is 95.1 per cent through a 100 mesh sieve and 80.9 through a 200 mesh sieve.

Tensile tests made by myself are as follows:-

7 day	14 day	21 day
134	222	196
113	190	222

Briquettes were made in the following proportions, 15 oz. sifted torpedo sand, 5 ounces cement and 2 1/2 ounces water

The initial set takes place in one hour and 12 minutes. From the figures shown above this cement evidently does not gain strength very rapidly after 14 days, although the initial set takes place quite soon.

The boiling test was O.K.

Milwaukee Cement.

Milwaukee cement is a natural cement manufactured a few miles outside the city of Milwaukee, from natural cement rock by the dry process. The raw material is burned in nine vertical kilns fitted with grates designed by the Superintendent, Mr. Campbell. The clinker is crushed with standard crushing machinery and Berthelet separators are installed. This cement is practically identical with old Newark Rosendale in character and composition. Tube mills are used to grind the clinker. The capacity of the plant is 500,000 barrels per annum.

The chemical composition of the cement is,

SiO_2	23.16
Al_2O_3	6.33
Fe_2O_3	1.71
Ca O	38.08
Mg O	18.38
Potash and Soda	5.27
CO_2 water and loss	7.07

This cement may be classed as a "magnesia" natural, due to the large quantity of magnesia present. Comparing with the analysis of Louisville natural, it will be seen that there is about 10 per cent more Mg O, 7 per cent less Ca O and three per cent less SiO_2 present in Milwaukee cement than in Louisville cement.

Lagerdorfer Cement.

Lagerdorfer cement is a Portland cement made near Hamburg in Germany. It is manufactured from clay and chalk by the wet process, without agitators. The slurry is made into bricks, which are calcined in vertical kilns and ground by means of buhr stones. Recently rotary kilns have been installed, increasing the capacity 1000 barrels per day. The cement, when the process of manufacture is completed, is stored in a magazine of 80,000 barrels capacity. The capacity of the Lagerdorf plant is 400,000 barrels per annum. Although no specific data can be presented, Lagerdorfer cement may be pronounced one of the best imported Portland cements.

The Chemical analysis is as follows:-

SiO_2		21.14
Al_2O_3		6.30
Fe_2O_3		2.50
Ca O		66.04
Mg O		1.11
Co_2	water and loss	2.91

The American agents for Lagerdorfer cement are the Kelley Island Lime & Transfer Co., Cleveland, Ohio.

Portland Cement.

Lehigh Portland Cement Co.'s Portland cement was used throughout the experiments. It is manufactured from clay and limestone by the wet process, without additions. The slurry is well mixed in rotating cylinders, burned in vertical kilns and ground by means of tube mills. Recently rotary kilns have been installed. Increasing the capacity 150% [illegible] the day. The cement, when the present manufacture is completed, is stored in a warehouse of 50,000 barrels capacity. The capacity of the Lehigh plant is 4000 barrels per annum. Although no specific data can be furnished, information cannot be procured any of the best Portland cements.

The Chemical analysis is as follows:-

SiO_2	21.14
Al_2O_3	6.35
Fe_2O_3	3.60
CaO	60.04
MgO	1.11
SO_3	[illegible] 2.41

The American Waterproofing Co., Cleveland, Ohio.

Lehigh Lime & Improved Co., Cleveland, Ohio.

Louisville Cement.

Louisville cement is a natural cement produced near Louisville, Kentucky. This cement is made from argillaceous limestone similar to that found in New York and Pennsylvania. The raw material is obtained from a quarry, the face of which is 15 feet deep, by means of steam drills and explosives and is broken and screened to three sizes, which are burned in three vertical kilns. The clinker is reduced by means of crackers and mill stones and separators are used. The quarry is situated near the bed of the Ohio river and the capacity of each kiln is 265 barrels per day.

The larger units of power in the plant are a 600 H.P. Corlis engine, a 300 H.P. Corliss engine and a 750 H.P. boiler.

Kentucky bituminous coal is used and the dry process is employed.

The chemical analysis of Louisville natural cement is as follows:-

SiO_2	26.40
Al_2O_3	6.28
Fe_2O_3	1.00
Ca O	45.22
Mg O	9.00
Potash and Soda	4.24
CO_2 water and loss	7.86

Farin de La Farge Cement.

As may be judged from the name this cement is of French origin and is also a Portland. In appearance this cement is lighter than any Portland cement I have ever seen; possessing a very light gray color. The fineness is about 96 per cent through a 100 mesh sieve.

The chemical analysis is

SiC_2	22.10
Al_2O_3	15.00
Fe_2O_3	3.21
Ca O	55.98
Mg O	0.37
$CaSO_4$	3.34

As may be seen from the analysis this cement has practically no Magnesia and is high in Alumina, the latter characteristic varying quite considerably from American and German practice. In lieu of definite data I would say that French cements are practically out of the question in American markets due to the high duty and in some cases doubtful quality.

Peerless Cement.

Peerless Portland cement is a Portland cement manufactured at Union City, Mich. The raw materials used are clay and marl and these are mixed in a ratio of 1 to 7 - 11. The clay is pulverized with Williams clay grinding machinery and the mixture is ground in wet tube mills. Rotary kilns, Wentz clinker coolers and Griffin mills are installed. Electric power is used throughout and the capacity of the plant is 1200 barrels per day.

The chemical analysis of the finished product is as follows:-

Ca O	62.6
$Si O_2$	20.3
Al_2O_3	7.6
Fe_2O_3	3.4
Mg O	1.7
SO_3	1.3
Alkalis	1.7
Loss	1.1

Tests made by Mr. O. Button show the following characteristics; fineness, 97 per cent passes 100 mesh sieve; 74 per cent passes a 200 mesh sieve; per cent of water used 21; per cent of gypsum present 2.46; initial set takes place in four hours and final set in 8 1/2 hours; boiling test O.K.

The tensile strength in pounds per square inch of neat briquettes was 85 pounds at the end of 24 hours, 555 pounds at the end of seven days, and 780 pounds at the end of twenty-eight days.

This cement is used quite extensively around Chicago, particularly for cellar and foundation work.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Universal Brand Cement.

This cement is a true Portland according to the definition, although made from slag by the Illinois Steel Company. The slag as it comes from the furnaces is sprayed with water to disintegrate the large masses, is dried in rotary driers and ground in ball mills. Limestone is then added and the raw material as a whole is ground in tube mills. The clinker is conveyed to rotary kilns, in which pulverized coal is used. This cement is manufactured at South Chicago and the regular slag cement is made at the works of the same company on the North side of the city. The total output from both plants is 50,000 barrels.

The chemical analysis is--

SiO_2	23.62
Al_2O_3	9.21
Fe_2O_3	2.71
Ca O	61.92
Mg O	1.78
SO_3	1.32
Loss	.52

Initial set takes place in two hours. Tensile tests, in which one part water, two parts cement and six parts sifted torpedo sand were used gave the following results:-

7 day	14 day	21 day
152	233	291, 292
181	240	302, 306

An average of many tests made on work here in the city is as follows:-

	24 hour	7 day
Neat	200	600
1 to 2 sand	70	280

Universal Brand Cement, Cont.

This cement possesses considerable tensile strength and its strength increases quite rapidly as may be seen from the figures.

The fineness determined on Fiehle U.S. Standard sieves is 97.8 per cent through a 100 mesh sieve and 86. per cent through a 200 mesh sieve. The boiling test was O.K.

This cement was used extensively in the new Brevoort Hotel for plaster and foundation work, and also by the Chicago & Northwestern Railway in their track elevation work at 16th street.

Utica Natural Cement.

As may be judged from the name, Utica cement belongs to the natural cement class and is produced at Utica, Ill. The finished product is made from natural cement rock and the plant contains the largest size of ball and tube mills, which is a novelty for a natural cement plant. Compressed air and electric light are furnished to the quarries and electric power is used throughout.

Another feature of this plant is the automatic weighing and loading. The raw material is burned in vertical kilns and the storehouse has a capacity of 150,000 barrels.

The fineness was found to be as follows:-

78.3 per cent passed a 100 mesh sieve and 69.5 per cent passed a 200 mesh sieve.

Briquettes consisting of one part water, three parts cement and three parts sifted torpedo sand gave the following results for tensile strength:-

7 day	14 day	21 day
72	153	148, 158
58	148	164, 167

The initial set takes place in from 20 to 40 minutes, which is quite rapid.

Wabash Cement.

Wabash cement belongs to the Portland class of cements and is manufactured at Stroh, Indiana; by the wet process. Clay and marl are the raw materials employed, and these are burnt in four rotary kilns, which have an aggregate capacity of 1200 barrels per day. As is customary in eastern and southern portions of the country pulverized coal is used as fuel. Ball and tube mills are used to grind the raw material.

The chemical analysis of Wabash cement is,

SiO_2	22.22
Al_2O_3	7.46
Fe_2O_3	1.80
Ca O	63.09
Mg O	2.83
SO_3	1.26
Loss	1.34

Mr. O. Button, Superintendent Burt Portland Cement Company made the following determinations:-

Fineness, 99 per cent passed 100 mesh sieve and 82 per cent passed a 200 mesh sieve; 1.90 per cent of gypsum is present; initial set takes place in four hours and final set in eight and one half hours; the boiling test was O.K.

Briquettes made neat with 21 per cent of water showed tensile strengths of 235 lbs. at the end of 24 hours, 590 lbs. at the end of 7 days and 675 lbs. at the end of 28 days.

Briquettes made of 3 parts sand and 1 part cement showed a tensile strength of 80 lbs. per square inch at the end of one day 250 lbs. per square inch at the end of 7 days.

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Whitehall Cement.

Whitehall cement is a true Portland from the Lehigh district, being produced at Cementon, Penna. This cement is a good example of an Eastern Portland cement. The rotary kiln, dry process is employed and the raw material used is obtained from the argillaceous limestone deposits in the immediate vicinity. The capacity of the plant is 1500 barrels per day and a very uniform cement is produced. In brief, the chief equipment of the works is four crushers, six ball and tube mills, twenty kilns, 45 feet long and 6 feet in diameter; and 8 batteries of ball and tube mills for clinker grinding. Electric power is used throughout and the cost of the plant was $700,000.

The fineness was determined to be as follows:-

92.4 per cent passed 100 mesh sieve and 73.6 passed a 200 mesh sieve.

Briquettes made for tensile tests and consisting of one part water, two parts cement and six parts sifted torpedo sand gave the following results:-

7 day	14 day	21 day
184	251	228
158	240	215

The briquettes made for the 21 day test were about the first moulded, and I don't believe it would be safe to say on the strength of the figures shown that the cement deteriorated after fourteen days.

Following are some results obtained by O.S.Dodge, U.S.N., Professor in charge of B'ld'gs. and G'rd's.,Annapolis, Md.

Initial set, 180 minutes; hard set, six hours twenty-five minutes; fineness, 99.8 per cent passes 50 mesh sieve; 95.75 per cent passes

Whitehall Cement, Cont.

100 mesh sieve; specific gravity 3.14.

The tests for setting in air and water and boiling test were all good.

Tensile strength lbs. per square inch

	24 hours	7 days	28 days	Per cent water
Neat	328	355	991	19.0
1 to 3 sand	79	399	459	9.5

Wolverine Cement.

Wolverine Cement is a Portland cement produced at Coldwater, Michigan. The plant employs the wet process and the capacity of the plant is 1500 barrels per day. The marl is obtained by dredging. The clay and shale are first ground in dry pans, and then the clay and marl are mixed in pug mills. The grinding is accomplished by means of tube mills, and the burning is done in rotary kilns. The clinker is ground in Griffin mills.

The chemical analysis of the material is as follows:-

	Clay	Marl	Cement
Loss	7.75 - 8.50		1.02
Organic matter		1.0 - 7.0	
$Si\ O_2$	58.75 -60.50		21.22
Titanium Oxide	.75 - .85		
Fe_2O_3	7.95 - 8.45		3.83
Al_2O_3	18.58 -19.40		7.51
Silicates		1.5 - 10.0	
Ca O	.95 - 1.25	88. - 98.	63.75
Mg O	1.20 - 1.45	.85- 1.25	.82
SO	.57 - .65		1.58

The mixture of marl and clay varies from 3.0 to 3.4 parts by weight of marl to one part clay.

The following are the results of tests made by Mr. O. Button, Superintendent of the Burt Portland Cement Company:-

Fineness, 97 per cent passes 100 mesh sieve and 74 per cent passes 200 mesh sieve.

	Clay	Marl	Coarse
Clays	7.00 - 1.00		1.00
Clays in multi-		1.0 - 7.5	
Li [illegible]	84.75 -60.00		11.00
Liberian Shale	.00 - .00		
[illegible]	7.00 - 1.00		1.00
Alluvium	11.00 -15.00		1.00
[illegible]		1.5 - 1.5	
[illegible]	.00 - 1.00	00. - 00.	00.00
[illegible]	1.00 - 1.00	.00 - 1.00	.00
[illegible]	.00 - .00		1.00

The [illegible] of marl and clay ranges from 1.0 to 3.1 grams by weight of marl to the part clay.

The following are the [illegible] of Shale mix by Dr. [illegible], [illegible] of the Bore Control Cement Company:-

"[illegible], 20 per cent passes 170 mesh sieve and 71 per cent passes 270 mesh sieve.

Wolverine Cement, Cont.

Initial set took place in 4 1/2 hours and final set in 8 1/2 hours. The boiling test was O.K.

Neat cement briquettes gave the following tensile strength in pounds per square inch; 24 hours, 210#; 7 days, 665#; 28 days, 825#.

This cement was used extensively in the drainage canal construction and by the Chicago & Northwestern Railway in their track elevation work at Sixteenth Street.

SANDS

The samples of sand collected by myself are as follows:-

Quartz, lake, torpedo, sifted torpedo, No.1 and No.2 torpedo and a mixture of No.2 and No.4; also granite siftings and crushed quartz.

The quartz sand is practically never used in concrete construction but is sometimes used for experimental purposes. The objectionable feature of this sand is its fineness, practically 100 per cent, passing a 50 mesh sieve. The voids were found to be 28.6 per cent.

Lake torpedo is usually an uneven mixture of material varying from a fine sand to a No.5 or roofing gravel size. This sand frequently contains unsound material and foreign substances. The sample obtained was taken from Lake Michigan. 34.8 per cent was retained on a 20 mesh sieve and 11.1 on a 30 mesh sieve, the remainder passing. The percentage of voids was found to be 26.1 per cent.

Sifted torpedo sand may be obtained almost any where and the sample came from St.Charles, Ill. It is a very good grade of sand for small work and I used it exclusively in making briquettes. This sand is of a siliceous character and the grains are clean and sharp. 21.2 per cent are retained in a 20 mesh sieve and 37.1 per cent on a 30 mesh sieve. The percentage of voids was 30.8.

The samples of No.1 and No.2 torpedo sand came from Carpenterville, Ill. Both samples are clean and No.1 is well mixed granulometrically. No.1 contains 28.5 per cent voids and No.2 contains 24.7 per cent voids, thus showing the effect of coarseness. 22.8 per cent was retained on a 20 and 20.5 per cent on a 30 mesh sieve for No.1

58.7 per cent was retained on a 20 and 16.2 per cent on a 30 mesh sieve for No.2. No.1 is used considerably for sidewalk and other light work, while No.2 is used for the heavier work.

The mixture of No.2 and No.4 also came from Carpenterville and is used by the C. & N.W. Ry. as a substitute for torpedo sand. 64.3 per cent was retained on a 20 and 18.9 per cent on a 30 mesh sieve. The percentage of voids is 23.8. The principal use made of this material by the railroad is for bridge work, where it is used in a 1 - 3 - 6 mixture for deadening fills and in a 1 - 2 - 4 mixture for reinforced coating.

The sample of granite siftings came from Elmhurst and possess 22 per cent of voids. 72.6 per cent was retained on a 30 and 6.7 per cent on a 30 mesh sieve. The size of the pieces vary from 3/8 of an inch to a fine dust. This material is used extensively for curb finishing, the popular mixture being 2 cement to 3 siftings.

The crushed quartz sample contains 41.7 per cent voids, and is very clean and uniform. This material is never used in concrete construction on account of its expensiveness.

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GRAVEL and CRUSHED STONE.

The samples of gravel that I obtained came from Carrie, Ill. They are numbers 7 and 8 and numbers 7 and 8 concrete. No.7 will pass a one inch ring and number 8 and 1 1/2 inch ring. As has been said before, sometimes the larger pebbles are cracked to make angular surfaces and finer material added, when a good concrete gravel is desired. I don't believe such was the case with the samples however, although the labels differ, because the voids present vary but slightly.

The voids present in numbers 7 and 8 and numbers 7 and 8 concrete were respectively 40.2 per cent, 42.3 per cent, 40.5 per cent and 41.2 per cent.

The samples of limestone are 1/2 inch, 1 inch and 1 1/2 inch. To all appearances the samples are clean, sound, solid and of quite a uniform size. Judging from the popularity of this material, it has evidently fulfilled requirements as regards strength and durability. This stone is obtained from several places in Illinois. The percentage of voids was found to be for the 1/2 inch, 44.4 per cent, for the 1 inch 41.1 per cent, and for the 1 1/2 inch 40.8 per cent.

BIBLIOGRAPHY

BOOKS

691.5 Brown
B81 Handbook for cement users

691.5 Cummings
C91 American cements

691.5 Sabin
Sa1 Cement and concrete

691 Ohio
OhGe Geological Survey of Ohio

691.8 Crushed Stone and Its Uses
J12 Arranged by W. J. Jackman

C. C. Brown
Directory of American Cement Industries

PERIODICALS

Standard cement specification (Lesley),
American Society for Testing Materials, 2 : 121.

Air separation of cement (Michaelis),
Cement and Engineering News, October, 1903. 15: 72.

Formulas for proportioning the raw materials in cement manufacture (Meade),
Cement and Engineering News, February, 1904. 15: 195-196

Marl as used in the manufacture of Portland cement,
Cement and Engineering News, February, 1904. 15 : 159

Rotary cement kiln
Engineer (London), June 16, 1905. 99 : 603.

Report of Board of Engineers, U.S.A, on the properties and testing of hydraulic cement,
Engineering News, 46 : 180-184.

Why separators are not used in Portland cement works,
Engineering News, 51 : 585.
51 : 612

Cement exhibits at St.Louis Exposition,
Engineering News, November 10, 1904. 52 : 407.

Effect of clay and loam on strength of Portland cement mortars,
Engineering News, August 10, 1905. 54 : 140.

The Edison Portland Cement Works at New Village, N.J.,
Engineering News, 50 : 555-559.

Plant of the Milwaukee Cement Co., (Campbell kiln and Berthelet separating system) (Lewis),
Engineering Record, 38 : 384.

Natural cement plant at Speeds, Indiana (Lewis),
Engineering Record, 38 : 312.

Whitehall Portland Cement Works,
Engineering Record, 42 : 244-246

Works of the Egyptian Portland Cement Company, Fenton, Michigan, (New marl cement mill),
Engineering Record, 49 : 320-321.

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